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Patentanmeldung Nr. | Patent application No. | Demande de brevet n°

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Transmit and receive antenna-switch

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Transmit and receive antenna-switch

The invention relates to a device such as a mobile terminal, such as a dual-band or multi-band mobile phone, or the like, or any other transmit and receive device, or to a module for such a device. Such a device comprises an antenna-switch for switching one or more transmitting branches each for transmitting signals via at least one frequency band, which antenna-switch is located between an antenna on the one hand and said transmitting branches and receiving branches, each for receiving signals via at least one frequency band, on the other hand.

The invention also relates to an antenna-switch for switching transmitting branches each for transmitting signals via an antenna and at least one frequency band, with at least two receiving branches each receiving signals via at least one frequency band and said antenna,

and to a method for switching transmitting branches each for transmitting signals via an antenna and at least one frequency band, with at least two receiving branches each receiving signals via at least one frequency band and said antenna.

Such dual-band or multi-band mobile phones are for example used in Time Division Multiple Access (TDMA) systems.

A prior art system is known from EP 1 152 543 A1, which discloses a hybrid radio frequency switching device. According to this device (Figures 8,9 of EP 1 152 543 A1), the antenna-switch comprises one diode for switching both transmitting branches. The first transmitting branch (Tx GSM) is coupled via a first low pass filter to a low pass + high pass filter, and the second transmitting branch (Tx DCS/PCS) is coupled via a second low pass filter to said low pass + high pass filter. This low pass + high pass filter is further coupled to said diode.

The known system is disadvantageous, inter alia, due to isolating branches in a complex way from each other, as a consequence of which the known system will have high Radio Frequency (RF) losses.

It is an object of the invention, inter alia, of providing a low cost device or module for such a device in which at least two branches are isolated from each other in a low complex way.

It is a further object of the invention, inter alia, of providing a low cost antenna-switch for isolating at least two branches from each other in a low complex way.

It is a yet further object of the invention, inter alia, of providing a method whereby at least two branches are isolated from each other in a low complex way.

The device or module according to the invention comprises

- at least two transmitting branches each for transmitting signals via at least one frequency band,
- at least two receiving branches each for receiving signals via at least one frequency band,
- an antenna-switch for switching said transmitting branches, and
- an antenna coupled to said branches via said antenna-switch,

wherein said antenna-switch comprises at least one first semiconductor switch coupled serially between a first transmitting branch and said antenna and at least one second semiconductor switch coupled serially between a second transmitting branch and said antenna and at least one third semiconductor switch coupled parallelly to at least one receiving branch.

By providing the antenna-switch with said semiconductor switches such as PIN diodes or MEMS switches or pHEMT switches, said transmitting branches and said receiving branch are well isolated from each other in a low complex way. During transmission via the first transmitting branch, the first and third semiconductor switch are conducting, with the second semiconductor switch being non-conducting. As a result, the high power transmission signals from the first transmitting branch cannot enter the second transmitting branch (non-conducting second semiconductor switch) and cannot enter said receiving branch (short circuited by the conducting third semiconductor switch). During transmission via the second transmitting branch, the second and third semiconductor switch are conducting, with the first semiconductor switch being non-conducting. As a result, the high power transmission signals from the second transmitting branch cannot enter the first transmitting branch (non-conducting first semiconductor switch) and cannot enter said receiving branch (short circuited by the conducting third semiconductor switch). During receival, all semiconductor switches are non-conducting. As a result, low power receival signals cannot enter both transmitting branches (non-conducting first and second

semiconductor switches) and can enter said receiving branch (which now is not short circuited by the now non-conducting third semiconductor switch).

In an embodiment of the device according to the invention, said antenna-switch is provided with the fourth semiconductor switch like for example a PIN diodes or a MEMS switch or a pHEMT switch. Herewith, said transmitting branches and said further receiving branch are still isolated from each other in a low complex way. During transmission, the fourth semiconductor switch is conducting, as a result, the high power transmission signals from the first or second transmitting branch cannot enter said further receiving branch (short circuited by the conducting fourth semiconductor switch). During receival, this fourth semiconductor switch is non-conducting, as a result, low power receival signals can enter said further receiving branch (which now is not short circuited by the now non-conducting third semiconductor switch). The combination of said third and fourth semiconductor allow the advantageous introduction of further elements as described below.

In an embodiment of the device according to the invention, one side of said third semiconductor switch is coupled to said at least one receiving branch and via an inductor to said first and second semiconductor switch and the other side is coupled via a capacitor to ground, with one side of said fourth semiconductor switch being coupled via said capacitor to ground and the other side being coupled to said at least one further receiving branch and via a further capacitor to said first and second semiconductor switch. By providing the antenna-switch with a capacitor, said third and fourth semiconductor switch are coupled to ground for Radio Frequency (RF) signals. Said inductor and said further capacitor provide a high impedance for high power signals originating from the transmitting branches and to be transmitted, and provide separation of high and low bands.

In an embodiment of the device according to the invention, the antenna-switch is made transmission-line-less, which is possible after having introduced said semiconductor switches, said inductor and said further capacitor, less components are used, which reduces the costs and the size and the high Radio Frequency (RF) losses of the system. In fact, said inductor and said further capacitor together replace one or more prior art transmission-lines.

In an embodiment of the device according to the invention, said first transmitting branch transmits in the 900 MHz band, said second transmitting branch transmits in the 1800/1900 MHz band, said at least one receiving branch receives via the 900 MHz band, and said at least one further receiving branch comprises a first further receiving branch for receiving via the 1800 MHz band and a second further receiving branch for receiving via the 1900 MHz band.

Especially for the 900 MHz band, the 1800 MHz band and the 1900 MHz band, but not exclusively, it is important to come up with a device and an antenna-switch having a simple topology.

In an embodiment of the device, said antenna-switch comprises at least one transmission-line of which one side is coupled to one side of said first semiconductor switch and to said antenna, with the other side of said transmission-line being coupled to said third semiconductor switch, and with a tap of said transmission-line being coupled to one side of said second semiconductor switch.

By providing the antenna-switch with the transmission-line, said first, second and third semiconductor switch are coupled compactly, and the receiving branches can be controlled (switched) according to a variety of possibilities. Instead of using one transmission-line with a tap, of course two serial transmission-lines can be used as well.

In an embodiment of the device according to the invention, said antenna-switch further comprises a transistor switch per receiving branch and coupled serially between said receiving branch and said transmission-line.

By providing the antenna-switch with a transistor switch per receiving branch, as a result of said third semiconductor switch together with said transmission-line during transmission protecting (short-circuiting) the receiving branches against high power signals originating from the transmitting branches and to be transmitted, these transistor switches can be of small size, and the size of system is further reduced. As a yet further result of this, the transistor switches, like for example GaAs pHEMT switches, can be replaced by MESFET or RF CMOS switches, which offers reduced dependencies from GaAs suppliers and, as a consequence, reduced costs. Compared to prior art solutions with one transistor switch per (transmitting and receiving) branch (and/or a number of serial transistor switches per transmitting branch due to high power transmission signals needing to be switched), the sixth embodiment has reduced high Radio Frequency (RF) losses (due to less transistors being in parallel and/or serially), and the large transistor switches for the transmitting branches are avoided (replaced by said transmission-line), resulting in a reduced size (these transistors switches had to be large for being able to switch the high power transmission signals).

Embodiments of the antenna-switch according to the invention and of the method according to the invention correspond with the embodiments of the device or to the module for the device according to the invention.

It should be observed that, due to just conducting during a transmission mode, with said transmission mode generally being active during shorter time-intervals than a

receiving mode, and with said transmission mode requiring so much transmission power that during the transmission mode any biasing power is irrelevant, said semiconductor switches can be any kind of semiconductor switches, like all kinds of diodes, all kinds of transistors etc.

The invention is based upon an insight, inter alia, that prior art branches are isolated in an expensive and complex way, and is based upon a basic idea, inter alia, that a serial semiconductor switch per transmitting branch and a parallel semiconductor switch for one or more receiving branches for short-circuiting these one or more receiving branches during transmission offer good isolation in a low cost and low complex way.

The invention solves the problem, inter alia, of providing a low cost system in which at least two branches are isolated from each other in a low complex way, and is advantageous, inter alia, in that the size of the system is reduced, with many further advantages and/or improvements as defined by the first to the seventh embodiment now being possible.

It should further be observed that, for example in dual-band or multi-band mobile phones in TDMA systems, it is important to isolate transmitting branches from each other, to isolate receiving branches from each other, and to isolate transmitting branches from receiving branches and vice versa.

These and other aspects of the invention will be apparent from and elucidated with reference to the embodiments(s) described hereinafter.

Figure 1 is a block diagram of a device with an antenna-switch according to the invention with four semiconductor switches, and

Figure 2 is a block diagram of a device with an antenna-switch according to the invention with three semiconductor switches, a transmission-line and three transistor switches.

The device according to the invention shown in Figure 1 is, for instance, a mobile terminal such as a dual-band or multi-band mobile phone. The device comprises antenna-switch 1 according to the invention, transmitting branches 2 and 3, receiving branches 4, 5 and 6, and an antenna 7. The shown device may be a complete ready-to-use apparatus but may also be a module for such a complete ready-to-use apparatus, such as an

RF front end module. Antenna-switch 1 comprises a first semiconductor switch 11 of which an anode is coupled to first transmitting branch 2 and of which a cathode is coupled via a capacitor 20 to antenna 7 and comprises a second semiconductor switch 12 of which an anode is coupled to second transmitting branch 3 and of which a cathode is coupled via capacitor 20 to antenna 7. Said cathodes are further coupled to a bridge circuit comprising two serial circuits coupled in parallel: the first serial circuit comprises an inductor 15 and a third semiconductor switch 13, of which inductor 15 is coupled to said cathodes and of which third semiconductor switch 13 is further coupled via a capacitor 17 to ground; the second serial circuit comprises a capacitor 16 and a fourth semiconductor switch 14, of which capacitor 16 is coupled to said cathodes and of which fourth semiconductor switch 14 is further coupled via capacitor 17 to ground. A common point between inductor 15 and third semiconductor switch 13 is coupled to first receiving branch 6 and via a capacitor 19 to ground. A common point between capacitor 16 and fourth semiconductor switch 14 is coupled to second receiving branch 5 and to third receiving branch 4 and via an inductor 18 to ground.

In the device according to the invention, the first semiconductor switch 11 is coupled serially between first transmitting branch 2 and antenna 7 (note that the term "coupled to" does not exclude other elements being present in between, like capacitor 20). The second semiconductor switch 12 is coupled serially between second transmitting branch 3 and antenna 7 (for the term "coupled to" see before). The third semiconductor switch 13 is coupled parallelly to at least one receiving branch 6 (note that the term "coupled parallelly" is used for expressing that third semiconductor switch 13 is not coupled serially between at least one receiving branch 6 and antenna 7; in view of the coupling between receiving branch 6 and antenna 7, said third semiconductor switch 13 is coupled parallelly to this coupling). The fourth semiconductor switch 14 is coupled parallelly to at least one further receiving branch 4,5 and coupled parallelly to said third semiconductor switch 13 (for the term "coupled parallelly" see before).

By providing the antenna-switch 1 with said semiconductor switches 11, 12, 13 and 14 like for example PIN diodes or MEMS switches or pHEMT switches, said transmitting branches and said receiving branch are well isolated from each other in a low complex way: During transmission via the first transmitting branch 2, the first and third and fourth semiconductor switches 11, 13 and 14 are conducting, with the second semiconductor switch 12 being non-conducting. As a result, the high power transmission signals from the first transmitting branch 2 cannot enter the second transmitting branch 3 (non-conducting

second semiconductor switch 12) and cannot enter said receiving branches 4, 5 and 6 (short circuited by the conducting third and/or fourth semiconductor switches 13 and/or 14). During transmission via the second transmitting branch 3, the second and third and fourth semiconductor switch 12, 13 and 14 are conducting, with the first semiconductor switch 11 being non-conducting. As a result, the high power transmission signals from the second transmitting branch 3 cannot enter the first transmitting branch 2 (non-conducting first semiconductor switch 11) and cannot enter said receiving branches 4, 5 and 6 (short circuited by the conducting third and/or fourth semiconductor switches 13 and/or 14). During receival, all semiconductor switches 11-14 are non-conducting. As a result, low power receival signals cannot enter both transmitting branches 2 and 3 (non-conducting first and second semiconductor switches 11 and 12) and can enter said receiving branches (which now are not short circuited by the now non-conducting third and fourth semiconductor switches 13 and 14), with filters (see below) in said receiving branches taking care of properly filtering these low power receival signals.

Capacitor 17 causes third and fourth semiconductor switches 13 and 14 being coupled to ground for Radio Frequency (RF) signals. Inductor 15 and capacitor 16 provide a high impedance for high power signals originating from the transmitting branches 2 and 3 and to be transmitted, and provide separation of high and low bands.

After having introduced said semiconductor switches 11, 12, 13 and 14, together with inductor 15 and capacitor 16, antenna-switch 1 can be made transmission-line-less, and less components are used, which reduces the costs and the size and the high Radio Frequency (RF) losses of the system. In fact, inductor 15 and capacitor 16 together replace one or more prior art transmission-lines.

First transmission branch 2 and first receiving branch 6 for example use the 900 MHz band, second transmission branch 3 and second receiving branch 5 for example use the 1800 MHz band, and second transmission branch 3 and third receiving branch 4 for example use the 1900 MHz band. Especially for these bands, but not exclusively, it is important to come up with a system and an antenna-switch having a simple topology. So other bands are not to be excluded, and further branches are not to be excluded, like for example a third transmitting branch and a fourth receiving branch for a fourth band, and/or the splitting of said second transmitting branch 3 into two subbranches 3a and 3b not shown, each one for its own band etc.

First and second transmitting branches 2 and 3 for example comprise (each or together) a power amplifier coupled to antenna-switch 1 via a filter per transmitting branch

2,3. This filter for example comprises a parallel circuit of a first inductor and a first capacitor, with each side of said parallel circuit being coupled to ground via a second/third capacitor and a first/second transmission-line, and with one side of said parallel circuit being a filter-input coupled to the power amplifier and with an other side of said parallel circuit being coupled to one side of a fourth capacitor of which an other side forms a filter-output coupled to the corresponding semiconductor switch and which other side is further coupled via a second inductor to a biasing in/output, which biasing in/output is further coupled to ground via a fifth capacitor. At least said second inductor and/or at least one capacitor of said filter are used for tuning a resonance frequency of the circuit comprising inductor 15 and capacitor 16.

First, second and third receiving branch 4, 5 and 6 for example comprise (each or together) a low noise amplifier coupled to antenna-switch 1 via a filter per receiving branch 4,5,6. This filter for example comprises a Surface Accoustic Wave (SAW) filter or Bulk Acoustic Wave (BAW) filter of which inputs are coupled to filter-inputs which are further coupled to each other via an inductor and of which an output is coupled to one side of a capacitor of which an other side forms a filter-output coupled to the bridge. For first and second receiving branch 4 and 5, both filters and both capacitors together with inductor 18 form a band separating network. Inductor 15 and capacitor 16 separate three (receiving) bands into two (receiving) bands plus one (receiving) band, which two (receiving) bands are separated from each other by means of for example said SAW filter(s) or BAW filter(s). As a result, semiconductor switches 11, 12, 13 and 14 can be cheap PIN diodes instead of using a more expensive pHEMT technology.

The biasing of the semiconductor switches 11-14 can be realised via a DC-current flowing from said biasing in/output via said second inductor and via said first/second semiconductor switch 11/12 and inductor 15 and third semiconductor switch 13 and fourth semiconductor switch 14 and inductor 18 to ground. It should be noted that the polarity of said semiconductors does not have any influence on the Radio Frequency (RF) signals, it is just of importance to the biasing situation. Preferably, the polarities are chosen in such a way that biasing currents are used at maximum efficiency: as shown in figure 1, one biasing current can be used for first/second semiconductor switch 11/12 and third semiconductor switch 13 and fourth semiconductor switch 14.

The device according to the invention shown in Figure 2 comprises antenna-switch 10, transmitting branches 2 and 3, receiving branches 4, 5 and 6, and an antenna 7. Antenna-switch 10 comprises a first semiconductor switch 21 of which a cathode is coupled

to first transmitting branch 2 and of which an anode is coupled via a capacitor 30 to antenna 7 and comprises a second semiconductor switch 22 of which a cathode is coupled to second transmitting branch 3 and of which an anode is coupled to a tap of a transmission-line 24,25. One end of this transmission-line 24,25 is coupled to the anode of first semiconductor switch 21, and an other end of this transmission-line 24,25 is coupled to a cathode of a third semiconductor switch 23. An anode of third semiconductor switch 23 is coupled via a capacitor 29 to ground. Said cathode of third semiconductor switch 23 is further coupled first main electrodes of three transistor switches 26, 27 and 28, of which second main electrodes are coupled to a third, second and first receiving branch 4, 5 and 6.

In the device according to the invention, the first semiconductor switch 21 is coupled serially between first transmitting branch 2 and antenna 7 (note that the term "coupled to" does not exclude other elements being present in between, like capacitor 30). The second semiconductor switch 22 is coupled serially between second transmitting branch 3 and antenna 7 (for the term "coupled to" see before). The third semiconductor switch 23 is coupled parallelly to at least one receiving branch 4,5,6 (note that the term "coupled parallelly" is used for expressing that third semiconductor switch 23 is not coupled serially between at least one receiving branch 4,5,6 and antenna 7; in view of the coupling between receiving branch 4,5,6 and antenna 7, said third semiconductor switch 23 is coupled parallelly to this coupling).

By providing the antenna-switch 10 with said semiconductor switches 21, 22 and 23 like for example PIN diodes or MEMS switches or pHEMT switches, said transmitting branches and said receiving branch are isolated from each other in a low complex way: During transmission via the first transmitting branch 2, the first and third semiconductor switches 21 and 23 are conducting, with the second semiconductor switch 22 being non-conducting. As a result, the high power transmission signals from the first transmitting branch 2 cannot enter the second transmitting branch 3 (non-conducting second semiconductor switch 22) and cannot enter said receiving branches 4, 5 and 6 (short circuited by the conducting third semiconductor switch 23). During transmission via the second transmitting branch 3, the second and third semiconductor switch 22 and 23 are conducting, with the first semiconductor switch 21 being non-conducting. As a result, the high power transmission signals from the second transmitting branch 3 cannot enter the first transmitting branch 2 (non-conducting first semiconductor switch 21) and cannot enter said receiving branches 4, 5 and 6 (short circuited by the conducting third semiconductor switch 23). During receival, all semiconductor switches 21-23 are non-conducting. As a result, low power

receival signals cannot enter both transmitting branches 2 and 3 (non-conducting first and second semiconductor switches 21 and 22) and can enter said receiving branches (which now are not short circuited by the now non-conducting third semiconductor switch 23).

By providing the antenna-switch with the transmission-line 24,25, said first, second and third semiconductor switch 21, 22 and 23 are coupled compactly, and the receiving branches 4,5,6 can be controlled (switched) according to a variety of possibilities, as described below. Instead of using one transmission-line 24,25 with a tap, of course two serial transmission-lines 24 and 25 can be used as well. And each transmission-line 24,25 can be replaced by the known equivalent in the form of a T-network or a Π-network respectively having one resp. two capacitor(s) to ground and two resp. one inductor(s) serially.

The transistor switches 26, 27 and 28 switch the receiving branches 4, 5 and 6, by controlling their control electrodes. They can be of small size, which further reduces the size of system, as a result of said third semiconductor switch 23 together with said transmission-line 24,25 during transmission protecting (short-circuiting) the receiving branches 4, 5 and 6 and the transistor switches 26, 27 and 28 against high power signals originating from the transmitting branches 2 and 3. As a yet further result of this, the transistor switches, like for example GaAs pHEMT switches, can be replaced by MESFET or RF CMOS switches, which offers reduced dependencies from GaAs suppliers and, as a consequence, reduced costs. Compared to prior art solutions with one transistor switch per (transmitting and receiving) branch (and/or a number of serial transistor switches per transmitting branch due to high power transmission signals needing to be switched), this embodiment has reduced Radio Frequency (RF) losses (due to less transistors being in parallel and/or serially), and the large transistor switches for the transmitting branches are avoided (replaced by said transmission-line), resulting in a reduced size (these transistors switches had to be large for being able to switch the high power transmission signals). Transmission-line 24,25 and third semiconductor switch 23 provide a high impedance for high power signals originating from the transmitting branches 2 and 3 and to be transmitted.

First transmission branch 2 and first receiving branch 6 for example use the 900 MHz band, second transmission branch 3 and second receiving branch 5 for example use the 1800 MHz band, and second transmission branch 3 and third receiving branch 4 for example use the 1900 MHz band. Especially for these bands, but not exclusively, it is important to come up with a system and an antenna-switch having a simple topology. So other bands are not to be excluded, and further branches are not to be excluded, like for example a third transmitting branch and a fourth receiving branch for a fourth band, and/or

the splitting of said second transmitting branch 3 into two subbranches 3a and 3b not shown, each one for its own band etc.

First and second transmitting branches 2 and 3 for example comprise (each or together) a power amplifier coupled to antenna-switch 1 via a filter per transmitting branch 2,3. This filter for example comprises a parallel circuit of a first inductor and a first capacitor, with each side of said parallel circuit being coupled to ground via a second/third capacitor and a first/second transmission-line, and with one side of said parallel circuit being a filter-output coupled to the corresponding semiconductor switch and with an other side of said parallel circuit being coupled via a fourth capacitor to a filter-input and via a second inductor to a biasing in/output, which biasing in/output is further coupled to ground via a fifth capacitor.

First, second and third receiving branch 4, 5 and 6 for example comprise (each or together) a low noise amplifier coupled to antenna-switch 1 via a filter per receiving branch 4,5,6. This filter for example comprises a Surface Accoustic Wave or SAW filter of which inputs are coupled to filter-inputs which are further coupled to each other via an inductor and of which an output is coupled to one side of a capacitor of which an other side forms a filter-output coupled to the corresponding transistor switch.

The biasing of the semiconductor switches 21-23 can be realised via a DC-current flowing from the anode of the third semiconductor switch 23 via transmission-line 24,25 and said first/second semiconductor switch 21/22 and said first inductors in the filters in the transmitting branches and the second inductors to the biasing in/output. It should be noted that the polarity of said semiconductors does not have any influence on the Radio Frequency (RF) signals, it is just of importance to the biasing situation. Preferably, the polarities are chosen in such a way that biasing currents are used at maximum efficiency: as shown in figure 2, one biasing current can be used for first/second semiconductor switch 21/22 and third semiconductor switch 23.

The transmission-line 24,25 will have an electrical length of about 90 degrees at 900 MHz, but can for example also be made smaller than 90 degrees. Said (for example second) capacitors in said filters (for example at the filter outputs) in the transmitting branches are used to tune this transmission-line 24,25. In case of the entire transmission-line corresponding with $\lambda/4$, each part (24 and 25) of this transmission-line will correspond with $\lambda/8$. As said before, one transmission-line 24,25 corresponding with $\lambda/4$ can be replaced by two serial transmission-line 24 and 25 each corresponding with $\lambda/8$.

The expression "for" in for example "for transmitting" and "for receiving" and "for switching" etc. does not exclude that other functions are performed as well, simultaneously or not. The expressions "X coupled to Y" and "a coupling between X and Y" and "coupling/couples X and Y" etc. do not exclude that an element Z is in between X and Y. The expressions "P comprises Q" and "P comprising Q" etc. do not exclude that an element R is comprises/included as well. The terms "a" and "an" do not exclude the possible presence of one or more pluralities.

The invention is based upon an insight, inter alia, that prior art branches are isolated in an expensive and complex way, and is based upon a basic idea, inter alia, that a serial semiconductor switch per transmitting branch and a parallel semiconductor switch for one or more receiving branches for short-circuiting these one or more receiving branches during transmission offer good isolation in a low cost and low complex way.

The invention solves the problem, inter alia, of providing a low cost device or module for a device in which at least two branches are isolated from each other in a low complex way, and is advantageous, inter alia, in that the size of the device is reduced, with many further advantages and/or improvements now being possible.

CLAIMS:

1. Device comprising

- at least two transmitting branches each for transmitting signals via at least one frequency band,
- at least two receiving branches each for receiving signals via at least one frequency band,
- an antenna-switch for switching said transmitting branches, and
- an antenna coupled to said branches via said antenna-switch,

wherein said antenna-switch comprises at least one first semiconductor switch coupled serially between a first transmitting branch and said antenna and at least one second semiconductor switch coupled serially between a second transmitting branch and said antenna and at least one third semiconductor switch coupled parallelly to at least one receiving branch.

2. Device according to claim 1, wherein said antenna-switch comprises at least a fourth semiconductor switch coupled parallelly to at least one further receiving branch.

3. Device according to claim 2, wherein one side of said third semiconductor switch is coupled to said at least one receiving branch and via an inductor to said first and second semiconductor switch and the other side is coupled via a capacitor to ground, with one side of said fourth semiconductor switch being coupled via said capacitor to ground and the other side being coupled to said at least one further receiving branch and via a further capacitor to said first and second semiconductor switch.

4. Device according to claim 3, wherein said antenna-switch is transmission-line-less.

5. Device according to claim 4, wherein said first transmitting branch transmits in the 900 MHz band, said second transmitting branch transmits in the 1800/1900 MHz band, said at least one receiving branch receives via the 900 MHz band, and said at least one further

receiving branch comprises a first further receiving branch for receiving via the 1800 MHz band and a second further receiving branch for receiving via the 1900 MHz band.

6. Device according to claim 1, wherein said antenna-switch comprises at least one transmission-line of which one side is coupled to one side of said first semiconductor switch and to said antenna, with the other side of said transmission-line being coupled to said third semiconductor switch, and with a tap of said transmission-line being coupled to one side of said second semiconductor switch.

7. Device according to claim 6, wherein said antenna-switch further comprises a transistor switch per receiving branch and coupled serially between said receiving branch and said transmission-line.

8. Device according to claim 7, wherein said first transmitting branch transmits in the 900 MHz band, said second transmitting branch transmits in the 1800/1900 MHz band, and said at least one receiving branch comprises a first receiving branch for receiving via the 900 MHz band and a second receiving branch for receiving via the 1800 MHz band and a third receiving branch for receiving via the 1900 MHz band.

9. Module for a device, said module comprising

- at least two transmitting branches each for transmitting signals via at least one frequency band,
- at least two receiving branches each for receiving signals via at least one frequency band,
- an antenna-switch for switching said transmitting branches, and
- an antenna coupled to said branches via said antenna-switch,

wherein said antenna-switch comprises at least one first semiconductor switch coupled serially between a first transmitting branch and said antenna and at least one second semiconductor switch coupled serially between a second transmitting branch and said antenna and at least one third semiconductor switch coupled parallelly to at least one receiving branch.

10. Antenna-switch for switching transmitting branches each for transmitting signals via an antenna and at least one frequency band, with at least two receiving branches

each receiving signals via at least one frequency band and said antenna, wherein said antenna-switch comprises

- at least one first semiconductor switch to be coupled serially between a first transmitting branch and said antenna,
- at least one second semiconductor switch to be coupled serially between a second transmitting branch and said antenna, and
- at least one third semiconductor switch to be coupled parallelly to at least one receiving branch.

11. Method for switching transmitting branches each for transmitting signals via an antenna and at least one frequency band, with at least two receiving branches each receiving signals via at least one frequency band and said antenna, which method comprises the steps of

- switching a first transmitting branch via at least one first semiconductor switch to be coupled serially between said first transmitting branch and said antenna,
- switching a second transmitting branch via at least one second semiconductor switch to be coupled serially between said second transmitting branch and said antenna, and
- switching at least one third semiconductor switch to be coupled parallelly to at least one receiving branch.

EPO - DG 1

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ABSTRACT:

Antenna-switches (1,10) in dual-band or multi-band mobile phones are according to a basic idea provided per transmitting branch (2,3) with a serial semiconductor switch (11,21,12,22) and with a further semiconductor switch (13,23) coupled parallelly to a receiving branch (4,5,6), to get isolation between branches (2-6) in a low complex way. Said semiconductor switches are PIN diodes or MEMS switches or pHEMT switches. Another semiconductor switch (14) coupled parallelly to the receiving branches (4-6) allows together with said further semiconductor (13) the introduction of transmission-line-less elements (15,16). Alternatively, the antenna-switch (1,10) may comprise a transmission-line (24,25), in which case the receiving branches (4,5,6) can be switched via transistor switches (26,27,28). This all improves the isolation, reduces the costs and the complexity and the size and the high Radio Frequency (RF) losses.

Figure 1

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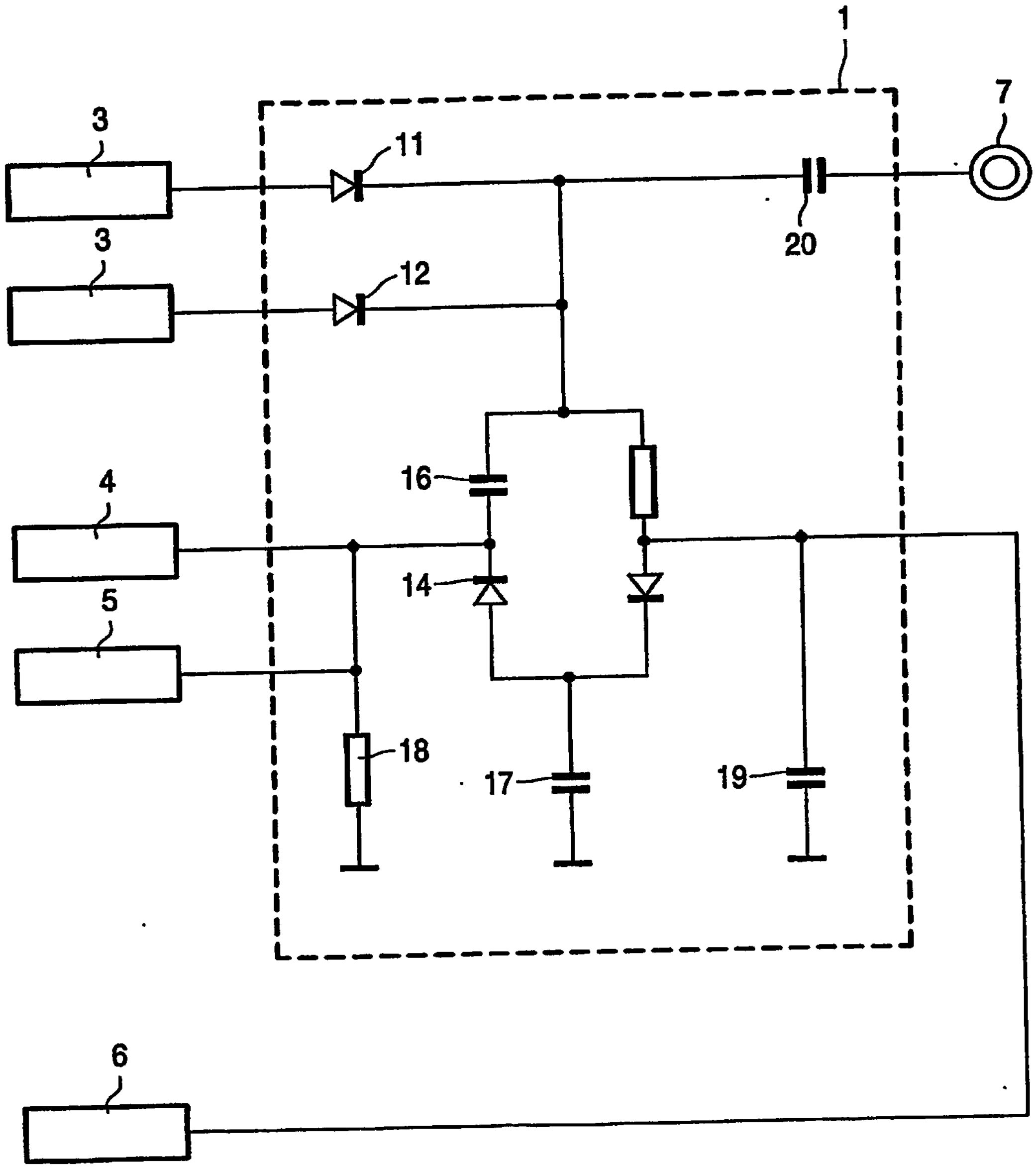

FIG. 1

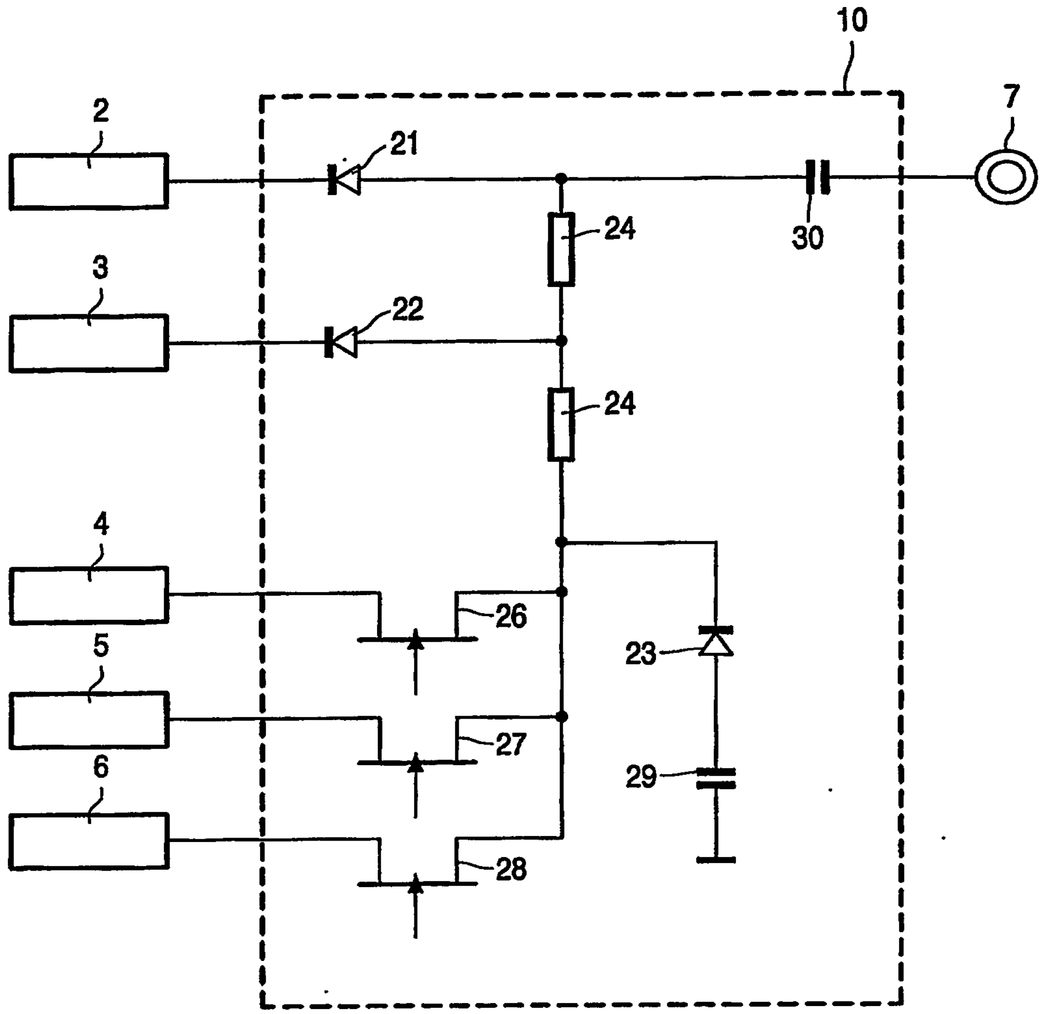

FIG. 2

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